Chapter 9

The Aquatic Staircase

In spite of continued efforts at navigation improvement by the Corps of Engineers after World War I, commercial use of the Mississippi River did not increase as much as had been hoped. Industry, manufacturers and other long-haul shippers seemed to have gotten out of the habit of water transportation.

The problems which shippers faced had little to do with the condition of the channel. Since the late 19th century, shippers and builders had made little attempt to adapt boat designs to either the new channel or to modern commercial needs, and as a result most boats were still too large, too underpowered, and too clumsy to haul freight profitably. Recognizing this, the Corps of Engineers had established an Experimental Towboat Board in 1910 under a $500,000 appropriation to design and construct two experimental towboats and several barges of a more modern design which could utilize the 6-foot channel. This Board met for many years, but never reached an agreement to actually build any boats.

A second problem was the lack of terminal facilities, especially rail-to-river terminals. In the 19th century boats had just pulled up to the waterfront to unload their barrels and bales without even the need for a dock. When terminals came to be a necessity because of the growing use of barges to haul the cargo in bulk form and because of the competition of railroads who were building their own terminals, no one seemed eager to accept the responsibility. Towns felt it was the responsibility of the steamboat companies, while the packet companies were nearly all too small to afford terminals, were financially strapped already by the railroad competition, and were too individualistic and competitive among themselves to band together to construct terminals. From the beginning the railroads had a much stronger corporate financial base than the packet companies which were run by entrepreneurs more than by boards of directors. Several state legislatures were considering bond issues for terminals as early as 1913, but the war put a stop to these plans.

As a result, it was the Federal government which finally led the way in revitalizing traffic on the Mississippi River. Word War I had drained much of the railroad equipment from the Mississippi Valley, leaving industry stagnant for lack of transportation facilities. Consequently, part of the Congressional appropriation of $509,000,000 under the Railroad Control Act of 1917 was assigned to the construction of boats and barges. In July 1918 the Government-organized-and-operated Federal barge fleet inaugurated service an the Lower Mississippi, using equipment commandeered from the Mississippi and Warrior Rivers, and from the New York Barge Canal.[1]

Federal involvement in river transportation expanded in 1924 when Congress authorized formation of the Inland Waterways Corporation to encourage increased use of commercial shipping on the Mississippi from New Orleans to St. Louis. By 1924, not one common-carrier barge line had begun operations on the Mississippi.[2] The Inland Waterways Corporation was to help stimulate such operations by demonstrating that inland water transportation could be economically successful, and by actually beginning regular barge service on routes that might eventually show a profit and be sold to private business.

Upper Mississippi interests did not take long to request similar Federal aid. In 1925 and 1926 several business groups in Minneapolis met with officials of the Inland Waterways Corporation and with Chief of Engineers General Harry Taylor tu see what could be done about extending service to the Upper Mississippi. The IWC had no boat of it3 own, so it made arrangements for Minneapolis interests to organize the Upper Mississippi Barge Line Company. In a lease executed on January 20, 1926, the Inland Waterways Corporation agreed to operate a fleet of boats and barges built by the new corporation from specifications furnished by the Secretary of War.

In order to examine the state of the channel so as to design boats accordingly, Colonel T. Q. Ashburn, Chairman of the Inland Waterways Corporation, traveled upriver to Minneapolis in April 1926 with barges loaded with ballast. Based on the findings of this trip, the Upper Mississippi Barge Line Company contracted Tar three towboats and 15 barges. The towboats, built by the Dubuque Boat and Boiler Works, were delivered in the spring af 1927 and put into service.

Meanwhile, the Government-run Federal Barge Lines extended service to the Upper Mississippi in 1926, scheduling two sailings each way from between St. Louis and St. Paul each week.

Under the impetus of this new traffic, river shipping gradually increased and several long-needed river terminals were planned. By 1928 terminals had been built at Burlington and Dubuque, Iowa, and one was under construction at Rock Island, A more general effect of this new traffic was that private and public groups along the Upper Mississippi began pressing Congress for a 9-foot channel between St. Louis and St. Paul similar to that authorized for the Ohio River in 1910 and now nearing completion. After the Upper Mississippi Barge Line Company turned their boats and barges over to Inland, they devoted their time to lobbying. Strong pressure for a 9-foot channel also came from the Upper Mississippi Waterway Association, the Upper Mississippi and St. Croix River Improvement Association, from Senator Henrik Shipstead of Minnesota, and from many other individuals and groups.[3] Prominent among these were industrial and real estate interests in Minneapolis, who viewed the 9-foot channel as a significant commercial boost for the region.

Rock Island District personnel were more cautious in their views of the new project. In vision, scope, and duration, the series of lacks and dams by which the Upper Mississippi would be turned into a commercial canal—an "aquatic staircase"—was larger than all of the former improvement works put together. The 1927 River and Harbor Bill authorized a Board of Engineers to survey the river from St. Louis to Minneapolis with a view to securing a 9-foot channel of suitable width. Rock Island District Engineer Major Charles L. Hall made a preliminary survey in August in 1927. Hall's report did not find the project economically warranted. The report met with a storm of protest from the pro-9-foot channel groups, who applied political pressure to Congress in this election year. Eventually, the report was returned to the Rock Island District Office with the request that a more detailed study be made. Hall had some support from Chief of Engineers General Edgar Jadwin.

Support also came from conservation and recreation groups such as the Izaac Walton League who were worried that the 9-foot channel would destroy the character of much of the 3010-mile Upper Mississippi Wildlife and Fish Refuge which had been authorized by Congress in 1924. In a speech to the School of Wildlife Protection in McGregor, Iowa, in August 1929, Hall shred their concerns. The 9-foot channel would create slack water stagnant pools that would alter the wildlife, drive animals away, and provide serious sewage disposal problems to the towns along the new channel.[4] Here again, Hall came in for criticism from those favoring the project, this time for taking ecological concerns into w-count.

A commonplace criticism of the Corps of Engineers is that it Invents projects to give itself work and expand its authority, and then pushes these projects through Congress, but a3 Raymond Merritt documents clearly *in* the St. Paul District history, when the 9-foot channel was finally authorized by the Act of July 3, 1930, it came in spite of feelings within the Corps of Engineers. In October 1929 President Herbert Hoover., who had just been elected President, replaced Major General Jadwin with a Chief of Engineers more favorable to the project, Major General Lytle Brown. As late as April of 1930, a list of public works projects authorized by Congress still did not contain the 9-foot channel. It appeared as part of the River and Harbor Act of July 3 that year without a final examination of surveys by the Corps, a victory, 33 Merritt suggests, "in which glory was shared by President Hoover, his secretary of war, the Mississippi Valley Association, the Minneapolis Real Estate Board, the Mississippi and St. Croix River Improvement Commission and congressional representatives from Minnesota."[5]

The Act of July 3 did not appropriate funds for the entire project, but there was $6,270,000 already appropriated for existing projects but not yet spent, and another $7,500,000 from Public Works and Emergency Relief Funds, and with these work on the project began. The authorization for the project specified that all locks below Minneapolis-St. Paul should not be less than the 110 by 600 feet established for the Ohio River. The Act of July 3 also authorized surveys for a 9-foot channel on the Illinois and Mississippi C a d and for portions of the Rock River.

In beginning this $170,000,000 project the Rock Island District entered a new era which brought, many visible changes. Where previous projects had been done *at* what now *seems* like a leisurely pace, the whole system of locks and dams was virtually completed in a decade, from 1930 to 1940. Much of the improvement work on the 4½-foot and 6-foot channels lay hidden under the surface in excavations and wing dams, but the 9-foot channel altered the shape of the river along nearly every mile, replacing the old Mississippi across which Sunday excursionists used to walk during low water with slack water pools, covering the bottom lands and creating countless willow islands where swamps had been. There was also the matter of money. The Rock Island District spent nearly as much money each year on the 9-foot channel as they had spent altogether on the 4½-foot channel.

Another significant difference between this and previous projects was the coordinated planning it involved. The 4½-foot channel project never developed a comprehensive plan. District personnel took so seriously the role of the Corps as "servant of the people" that they habitually waited for Congressional appropriations and directions to plan for the coming year.

The result had been a lack of uniformity in both planning and in results. Major Riche complained in 1910 that In the two districts in his charge (he was still District Engineer of the Second Chicago District), them were 40 locks in five different sizes. These varied from the small 170-foot by 35-foot locks of the Illinois and Mississippi Canal to the Moline Lock at 350 by 80 feet. This lack of uniformity continued when a Board of Engineers fixed the new power company lock at Keokuk at 358 by 90 feet, and when Congress authorized the La Claire Canal with a 350- by 80-foot lock. In contrast, the new 9-foot channel project produced locks identical in almost every respect.

The 9-Foot Channel Project

The decade of the 1930's was the most exciting period the Rock Island District had ever experienced as it rose to the demands of the 9-foot channel project. The interest generated by the project in towns along the river, the scope of the work, the challenge of something so different from and larger than previous projects, and the Great Depression itself all served to generate a feeling of teamwork that would be the envy of most other multi-million-dollar corporations.[6] The 9-foot channel boosted local economies and provided jobs for hundreds of professionals and skilled workers as well as for thousands of laborers. Many employees who came to work on the locks and dams in the 1930's remained with the District and kept up the spirit of teamwork long after the project was completed, During the past few years they have nearly all retired.

For both employees and area residents, the symbol of this change from old to new was the move of the Rock Island District Office in 1934 from the overcrowded quarters in the Federal Building where it occupied the second and third floors above the post office, to its o m building on Arsenal Island. Storehouse A, popularly known in the area a3 the Clock Tower Building, was the first building constructed for the Rack Island Arsenal i~ 1864. Abandoned almost immediately as the remainder of the Arsenal located further eastward on the island, the Clock Tower Building adjacent to the first of the locks and darns planned for the 9-foot channel, made an ideal location for the District. The building quickly came to stand for the District in the minds of area residents.[7]

When the District Office moved into the Clock Tower Building, personnel found themselves with a clear view of the new Locks and Dam 15, begun in 1931 and now virtually complete. Much work already lay behind this new construction.

The first task of the Engineers on the 9-foot Channel project was to establish a large real estate and lands section. Because of alterations of the shoreline mused by pooling the water and thus raising the water level, virtually every square foot of bath sides of the Mississippi had to be surveyed.

Bath natural conditions and papulation concentrations along the river determined the design, h a tion and number cl darns in the project. The low banks of the Upper Mississippi in front of a heady cultivated flood plain, and ths close encroachment of railroad tracks and towns precluded the construction of a few high dams. This meant that the dams had to be limited to navigation control and would not be able to serve as either power or flood structures, Law dams were also needed if the m a l levee systems were to be kept intact. On the other hand, the shallowness of the river itself precluded the use of dams like those on the Ohio River which could be lowered beneath the surface to pass the water during high river stages.

The kind and frequency of floods in the Upper Mississippi Valley also mads certain demands on the design of darns. The frequent concurrence of flood discharges from the whole basin indicated the desirability of moveable dams that could be raised entirely aut of the water during flood stages. Then, too, the ice which broke up in spring came downstream with considerable force. Any dams on this section of river would have to be both strong, and have wide enough openings to prevent constricting the flow of ice so as to cause ice jams.

There were also considerations apart from navigation and flooding. From the preliminary planning on, the Corps of Engineers cooperated with other agencies to minimize problems the dams might cause. The low dams could not be used for power generation or flood control, but the Corps did work closely with the Bureau of Biological Survey and the Bureau of Fisheries, and made several modifications in design to aid area ecology. For instance, the roller gate design which was selected permitted migration of fish, stabilized water levels, passed silt and sewage, aerated the water to keep oxygen levels up, and in this way benefitted both wildlife and public health. Cooperation of the National Park Service was obtained to insure that areas needed for navigation but not continuously overflowed would be put to maximum recreational use consistent with the project.[8]

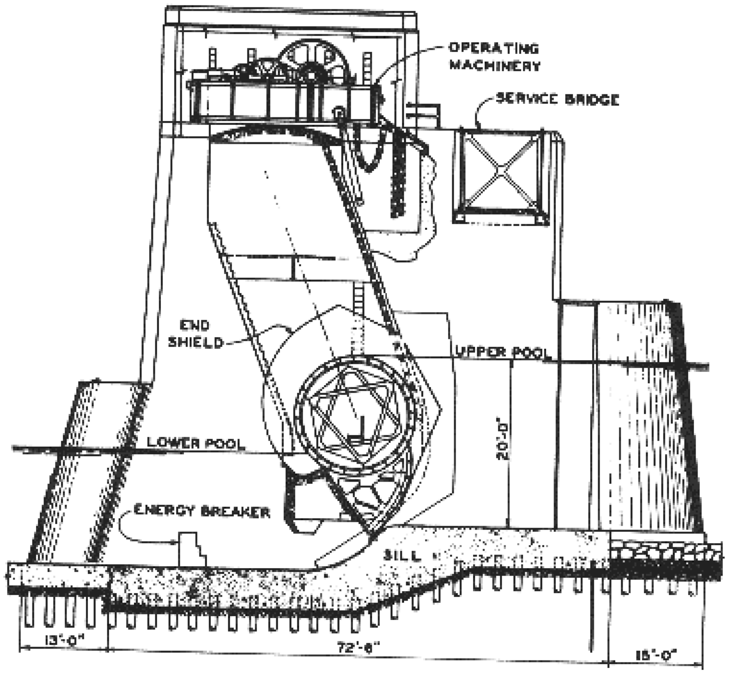
The 9-foot channel resulted from a series of 26 locks and dams between Minneapolis and Alton, Illinois, an "aquatic staircase"[9] hopping 335 feet over 662 miles. The lowest lift of any of these locks is 6.5 feet at Lock No. 5A at Winona, and the highest lift is 98.2 feet at the Keokuk Power Dam, now

Lock 19. The Rock Island District built 12 of these locks and dams, from No. 10 at Guttenberg, Iowa, to No. 22 at Saverton, Missouri. Much later, between 1952 and 1957, the District replaced the lock built by the power company at Keokuk with a new Lock 19.

The designing of the locks and dams was begun at the Upper Mississippi Valley Division Office in St. Louis. All of the locks were designed here, as well as all of the electrical work. Contracts for lock machinery were also let by the Division. However, after the designs of the first two dams constructed, Nos. 15 at Rock Island and 20 at Canton, Missouri, were completed by the Division, the responsibility for designing the remaining dams within District boundaries was turned over to the Rock Island Office.

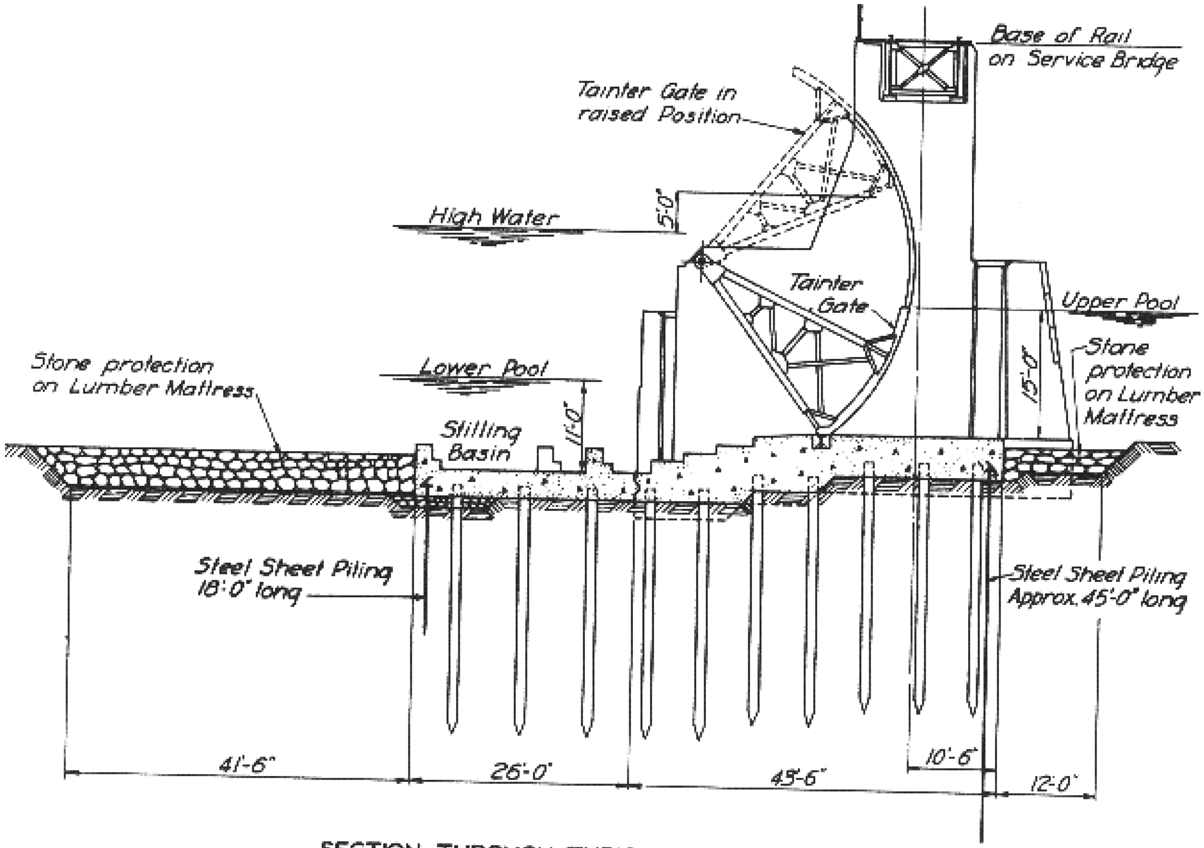
With the exception of Dam 15, all dams were designed with a combination of Tainter and roller gates. The decision to incorporate the newer roller design in the project was due to the need for dams on the Upper Mississippi which could withstand hard usage and which would provide as wide a space as possible between the piers so as to pass ice and drift. Rollers were structurally sounder, and so could be made longer. Dam 15 was built entirely with roller gates because it was constructed at the narrowest part of the channel and was subject to ice jams.[10]

Tainter gates were an old French design. This gate was essentially a pie-shaped wedge of cylinder, with the point downstream and the circumference arc made of metal sheet. The point of the Tainter gate was hinged between piers, and the curved surface upstream formed a dam against the water. The gate could be moved up and down so a3 to vary the amount of water flowing under the gate from nothing to a completely unobstructed flew when the gate was lifted entirely above the surface of the water. Tainter gates were used wherever possible because they were cheaper to construct, and because they did not require royalty payments as did the rollers, Cross section of a typical roller gats. Water flaws under the roller, tha amount controlled by raising or lowering the roller.



TYPICAL SECTION OF A ROLLER GATE

A similar view of a Tainter gate used along with rollers on most of the darns on the Mississippi. Tainter gates were not thought to be as sturdy as rollers, but as confidence in them grew. they were used in larger numbers.



SECTION THROUGH TYPICAL TAINTER GATE

Originally it was the intention to use the roller sections of the dam to pass the normal flow of water, reserving the use of the Tainter gates for flood time or high water. However, District engineers soon discovered that such an uneven flow of water through the dams caused extensive scouring below the dam, endangering the structures and playing havoc with the channel. Since then, all gates in a dam have been kept at about the same level. (This created problems at a dam like No. 20 at Canton, where the 40 Tainter gates were moved by a traveling crane—a slow process if one is attempting to keep them even. Ironically, water flow is more critical at No. 20, since it is the first dam below the mouth of the Des Moines River.)

The roller gate had been developed in Germany and was still under patent when the dams were built. Over 100 roller dams had been built in Europe, but they were quite new as far as navigation projects in the United States were concerned. The first roller dam had been built in Washington in 1912. There were nine other such dams in the United States before 1930.

The roller gate was essentially a hollow cylinder which could be raised or lowered to control the level of the water passing underneath. On the upstream side of the roller a steel apron extended along its length, When the gate was closed, the lower edge of this apron rested against a steel sill even with the riverbed. In addition to their strength, roller gates had the additional advantage of offering less friction to water passing underneath than other types of darns.

With the exception of Dam 15, all of the other dams an the 9-foot project contained roller and Tainter gates, and most of the others contained a fixed, or dike, section made of earth or, less often, concrete. These fixed sections contained a combination of spillways, overflow sections and non-overflow sections depending on the requirement of a particular area.

As the construction progressed in the 1930's, advances in both design and materials permitted the construction of wider Tainter gates, decreasing the need for rollers. In 1930 the limits of a Tainter gate were thought to be 40 feet, but this gradually increased. Dam No. 17 at New Boston, Illinois, completed in 1939, had eight 60-foot Tainters and three rollers; and Dam 13 at Clinton, Iowa, also completed in 1939, had ten 64-foot Tainters and three roller gates.

Most of the dams were designed solely for navigation. However, power is still generated at Dam No. 1 (completed in 1915 before the 9-foot channel project) under a license from the Federal Power Commission by which the Corps is reimbursed for power expenses. Water power is also used to generate small amounts of hydroelectricity at Dams 2 and 15 to operate lock machinery.

Although the general location of the dams was determined to a great extent by the rate of fall in various sections of the river, the exact location was determined by considering the locations of the towns along the shore. Wherever possible, dams were located just above towns so as to minimize any changes to the waterfront. The shorelines were changed least just below the dam in the system, and most just above the dams where the pools of water retained by the dams were deepest.

All of the locks in the Rock Island District are a uniform 110 by 600 feet, with the exception of Lock 19 at Keokuk, built in 1913. Lock 19 was 110 by 358 feet until it was replaced by a new lock in 1957. Each of the dams also contained an uncompleted auxiliary lock 110 feet wide and 269 feet long. Only the auxiliary lock at Dam 15 was completed. All of the locks use miter gates electrically operated, and a gravity fill system in which water enters or leaves the lock chamber by tunnels underneath the bottom of the lock.

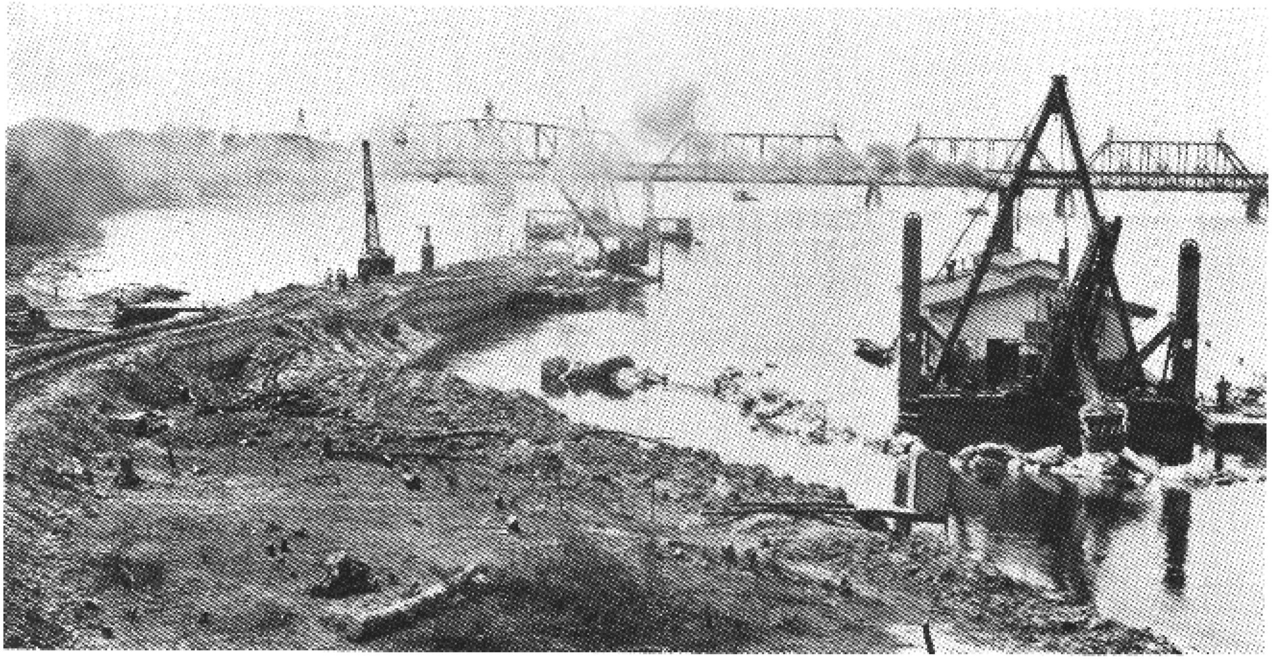
Locks and Dam 15. The first lock and dam to be constructed was No. 15 at Rock Island, located on the downstream tip of Arsenal Island just above and below the Government Bridge which connects Arsenal Island to Davenport. The dam is situated on a diagonal, pointing downstream from the south abutment at a 16½-degree angle to the normal channel line. The maximum head or difference in pool elevation is 16 feet.

In all cases the locks were built first so as not to interrupt river traffic. The contract for two parallel locks at Dam 15 was let on April 23, 1931. By June 30 the contractor had nearly completed the cofferdam around the south approach to the drawspan of the Rock Island Bridge (which the new locks would utilize). The main lock was completed on March 20, 1932, less than a year later, and in April construction of the auxiliary lock began, The purpose of the auxiliary locks at each dam was to take care of a projected future increase in traffic.

Both Locks at Dam 15 are 110 feet wide. The main lock is a standard 600 feet long, while the auxiliary lock is 360 feet. Guide walls approximately 40 feet high extend 600 feet upstream from the upper gate and 1,100 feet downstream from the lower gate, The top widths of these walls; vary from 6 to 40 feet, the wider portions serving to provide room for equip ment, machinery, and storage and shelter houses.

Water enters or leaves the lock chamber through four tunnels, two for each lock. Those in the main lock are 12½ feet square; those in the auxiliary lock are 10 feet square. The tunnels take water from the pool above the lock chamber and discharge into the river below the chamber. Two Tainter valves in each tunnel, one just downstream from the intake and one just upstream from the discharge parts, control the flow of water in and out.

When bringing the chamber level up to that of the upper pool, the lower valves are closed and the u p per opened. The water flows into the lock chamber from the tunnels through 4- by 3-foot openings spaced 25½ feet apart in the main lock and 20 feet apart in the auxiliary. When the water in the lock chamber equals the level in the upper pool, the upper gates are opened to let boats in or out. Water flows out these same openings into the tunnels when lowering the chamber level to that of the lower pool.



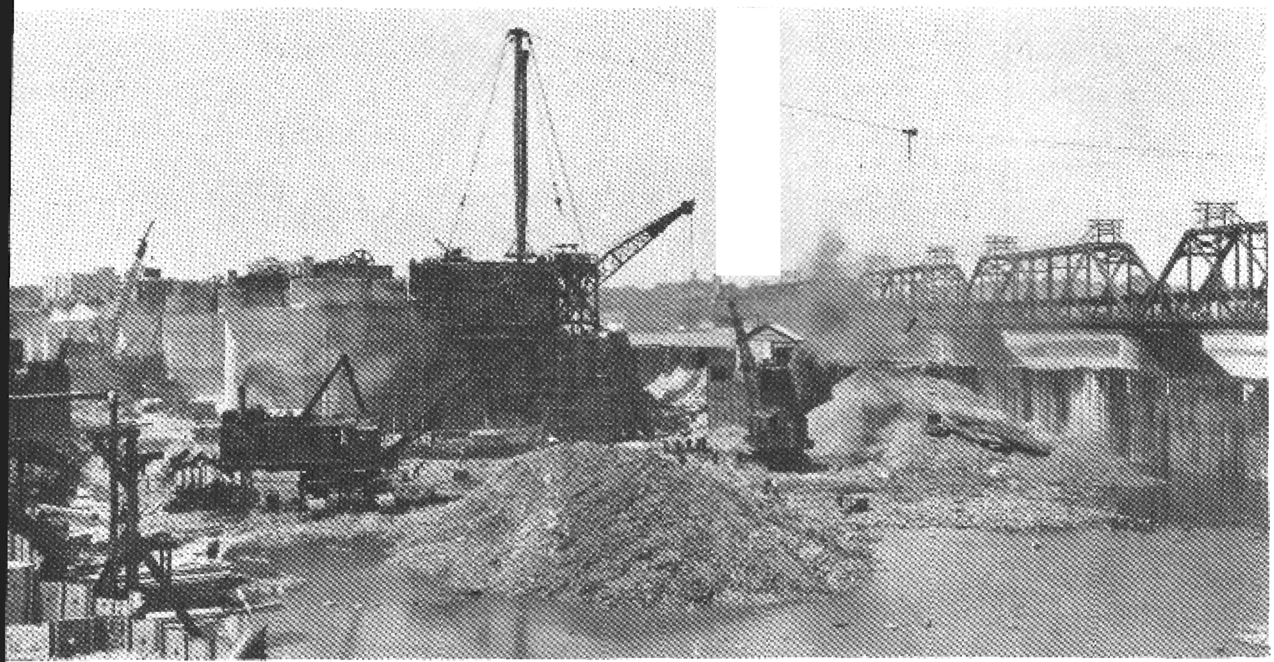
Initial construction on the 9-foot channel began with this coffer dam at Lock 15, adjacent to the new headquarters of the Rock Island District.

Bath upper and lower lock gates are miter gates opening upstream. Each leaf of each gate is operated by a 25-horsepower electric motor.

The contrast for the roller dam and appurtenant sea wall and intercepting sewer was let on February 8, 1932, and work got under way in the spring. By the end of the first fiscal year of work on the 9-foot channel, the Rock Island District had completed $3,132,814 of work.

Dam 15 was built on a limestone ledge lying 3 to 7 feet below a layer of silt, clay, sand, and broken rock forming the riverbed. As excavation for the dam progressed, a number of cavities (including four very large ones) were uncovered. These were cleaned of debris and filled with concrete.

The moveable section of Dam 15 is made up of 11 roller gates each 99.3 feet long, mounted between concrete piers. On each cylinder a steel apron 13 feet wide extends full length along the upstream side, Both ends of each gate have cast steel teeth partially encircling the cylinder; these teeth fit into cast steel racks set into the sides of the piers on an incline. The gates are raised or lowered by a link chain



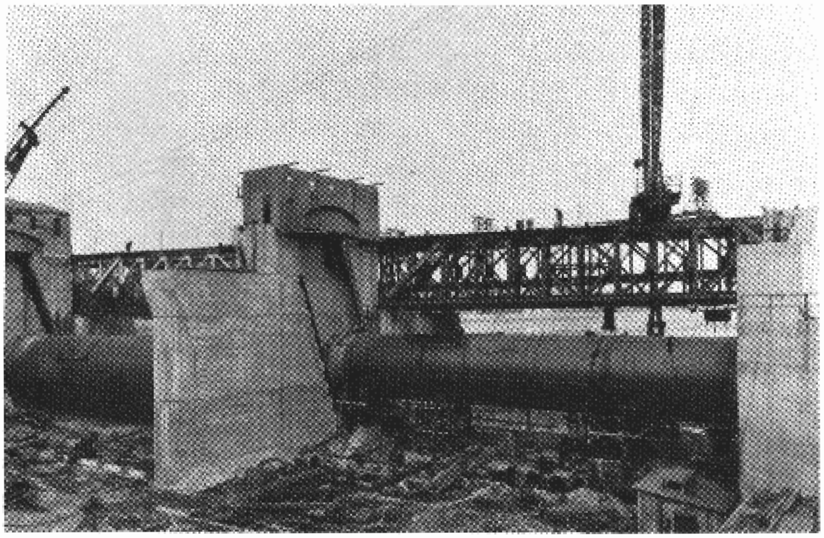
Construction on Dam 15 at Rock Island shows its location just downstream from the Rock Island Bridge. lock 15 utilizes the original drawspan of that bridge.

at the end of each roller, powered by individual 50-horsepower electric motors.

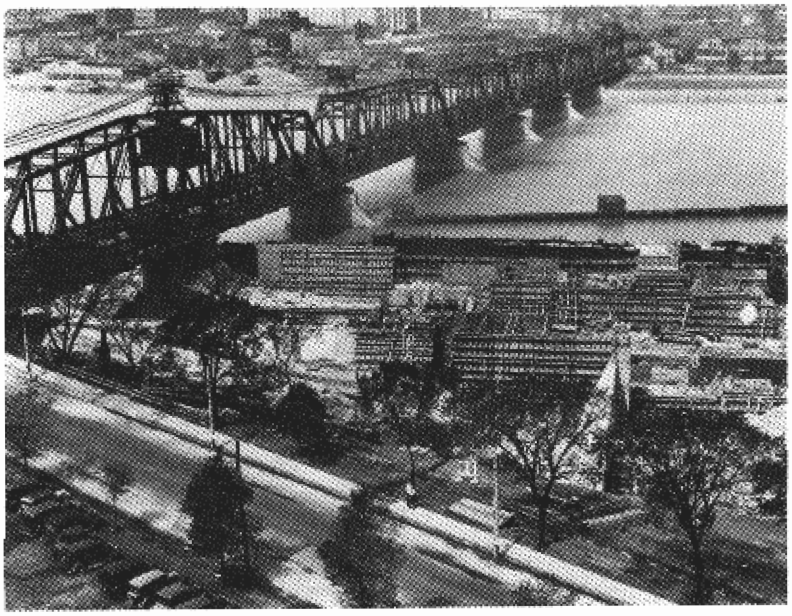
Nine of the rollers in Dam 15 are 19 feet, 4 inches in diameter, The ones nearest the Iowa and Illinois shores are 16 feet, 2 inches. These end gates, called skimmer gates, permit an overflow to keep the surface of the upper pool free of debris. The other rollers never overflow. The height of the rollers closed, including the apron, Is 26 feet for the main gates and 21 feet, 9 inches for the smaller end gates.

The roller gates are operated to keep a pool elevation of about 561.0 feet above sea level, or a minimum channel depth of 9 feet at the upstream end of the upper pod. The rollers are raised gradually as water flow increases, beginning with the center and working outward. The two end gates are always left slightly raised. On the Iowa aide this insures that there is always moving water at the sewer outlet, while moving water on the Illinois side provides good water for Rock Island's water supply intake.

On the Iowa side, the major problem caused by the locks and dama was that raising the water in the pools interfered with many urban storm and sani-



Roller gates in place at Dam 15.



Construction at Lock 15.

tary sewers, including those in the cities of Davenport and Bettendorf, where some 60 outlets were affected. To take care of this problem, a seawall and intercepting sewer were constructed from a point 136 feet below the first roller gate upstream marly two miles to where the natural bank gave protection. At this point the seawall ended and a concrete box sewer of gradually diminishing size, covered by a rip rapped earth levee, extended upstream to near Duck Creek in Bettendorf, about 4½ miles from the outlet. Five sluice gates were provided in order to allow the river to flush the sewer.

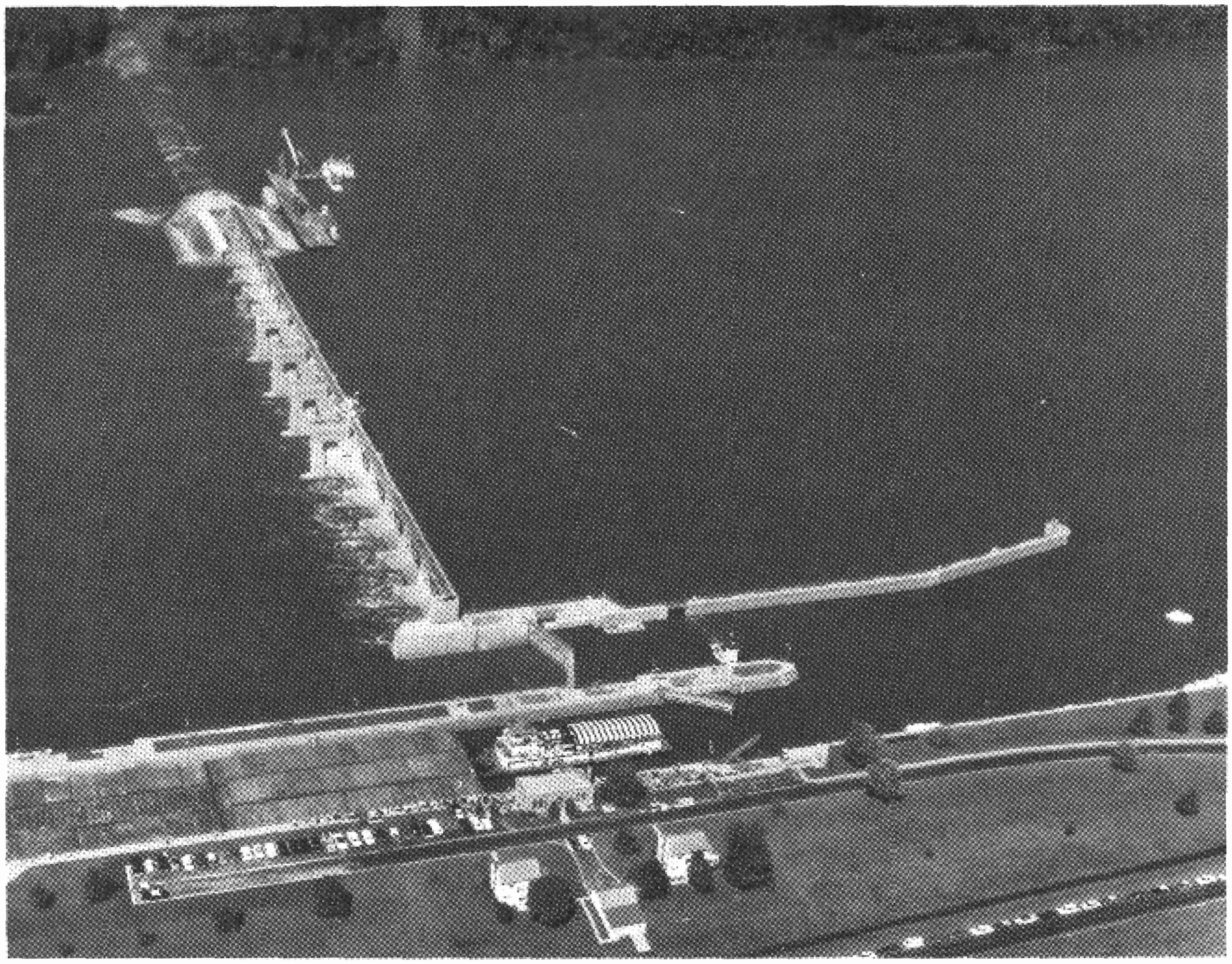
A steel truss service bridge extends over the entire length of the dam on the upstream side, On this bridge a 15-foot-gauge track supports a 30-ton electric crane with a 50-foot boom, used to service the heavy gate machinery and remove large pieces of debris. On the lower chord of the service bridge Is a bridge crane used to place emergency bulkheads in front of the roller gates. These bulkheads are trussed skinplates which fit in slots on the up stream aide of the piers, forming a cofferdam so that the roller gates can be removed for overhaul or repair,

The control house for the darn is on the wall at the south end of the dam. Here a 312-kilowatt generator puts out electricity to run the lock gates and the roller gates. The excess power, if any, runs to the Clock Tower Building for use there. The waterwheel that runs the generator lies 12 feet below the surface cl the river. A backup diesel unit is added to the system when the generator falls short, as it does during high water periods.

Locks and Dam 15 was opened to traffic in the spring of 1934. The machinery was installed in the locks by March 31, and the roller dam was completed on May 9. The total cast of the installation to its completion in 1934 was $7,480,000.

Other Locks and Darns. The construction of the remaining locks and dams followed much the same steps as Locks and Dam 15. Following the design of Dams 15 and 20, the Upper Mississippi Valley Division turned over the design of the remaining dams to the Rock Island District, where a force of 200 engineers, many of whom had been out of work because of the Depression, worked on the project. The overall design of the remaining dams was supervised by James Reeves and Edwin Franzen, while Frank Ashton had responsibility for the dam gates.

Major Raymond A. Wheeler arrived as District Engineer in the fall of 1933 to supervise the construction of five more locks and dams. Lack and Dam 20 was begun in November, as was No. 18



An overview of Lock and Dam 21 at Quincy, Illinois, showing components similar to those at most of the dams: locks, Tainter and roller gate sections, spillway: and levee.

north of Burlington, Iowa. In December work began on Nos. 16, 11 (at Dubuque), and 12 (at Bellevue). In deciding on the order in which to build the locks, Engineers followed the old practice of starting with the worst spots and ending with those having the least problem, Locks and Dam 15 had been the first because of continued problems with the Rock Island Rapids.[11]

Funds for the 9-foot project came from several sources in addition to the regular River and Harbor appropriations. On June 16, 1933, $33,500,000 was allotted from the National Industrial Recovery Act, and in 1934 additional funds amounting to $50,500,000 were allotted by the Federal Emergency Administration of Public Works. With this money work proceeded at a rapid rate. The total cost of work in the Rock Island District during fiscal 1934 was $6,390,467.47, more than double the amount spent during the first year of the project.[12]

In 1935 the River and Harbor Bill of August 20 authorized an appropriation of the entire amount required for completion of the project. Most of the funds had previously come from the Public Works and Emergency Relief funds. For example, in fiscal 1935 regular River and Harbor appropriations paid for $51,906.98 of new work, Emergency Relief funds had paid for $19,302.23, and the rest, $11,488,434.03, came from the Public Works Administration.[13]

Lock 10 at Guttenberg was placed in operation on May 25, 1936, even though the dam was not yet done. Later that year operation and maintenance of this lock and dam was transferred to the St. Paul District. By 1939 the last of the locks and dams were nearing completion. Nos. 12, 21, and 22 were finished in 1938. In April 1939 Nos. 13 and 17 were completed and in June the last lock, No. 14 at Le Claire, was opened to navigation. Lock and Dam 14 had been left until last because the Le Claire Canal built in 1922 already provided a fairly good channel over the upper section of the rapids. Lock 14 was built adjacent to the Le Claire Lock at the foot of the Le Claire Canal. Completion of Lock and Dam 14 at a cost of $5,472,000 marked the beginning of a new era in Upper Mississippi transportation, and the end of the last section of the long-troublesome Rock Island Rapids.

Since 1969 the old Le Claire Canal and Lock has been used as an auxiliary lock for the passage of recreational craft. Beginning in 1969, it has been available for use only on summer weekends. A major renovation project was begun at the Le Claire Lock in 1979 and completed in 1981. New lock gates and machinery were installed, lock walls were repaired, and a new lock house was constructed. The old canal grounds now house the Corps of Engineers Le Claire Base, consisting of the motor shop, a warehouse to store equipment, and offices for personnel from the overcrowded Clock Tower Building.

By June 30, 1940, a controlling depth of 9 feet had been reached in all pools in the Rock Island District at a total cost to that date of $69,609,229.44. The original estimate for the entire project in 1931 had been $140,000,000, but this was gradually revised upward by 1940 to $170,000,000, partly due to changes and additions made to the project as it went on.

The one lock that still did not come up to standard dimensions in 1940 was Lock 19 at Keokuk, which had been built by the power company. The same act which authorized the 9-foot channel in 1930 also authorized a second lock at Keokuk to meet the standard 110- by 600-foot dimensions. The lock built by the power company, which also lacked the 9-foot depth required, would become the auxiliary lock.

Planning for this, new lock was begun by the Rock Island District in 1930, but there were problems with its location. Building the new lock east of the existing one would interfere with the power plant, while a new lock on the landward side of the dry dock would isolate the dry dock from land, making the delivery of supplies difficult.[14]

To overcome these problems District engineers first planned to build the new lock immediately downstream of the dry dock and connected to it. The dry dock would then be used only in emergencies or during the closed navigation season. The first estimate of the cost of the new lock was $1,500,000.

Between 1936 and 1937 the Rock Island District made *many* studies of locations for the new lock. These included building landward or riverward of the existing lock, enlarging the existing lock, extending the dry dock to create a 600-foot lock, and using the site of the dry dock itself. These studies concluded with a plan to build the lock at the dry dock site and build a new dry dock landward of the lock. The design of t i s lock was to be consistent with the other locks on the 9-foot channel project, most of which were now nearing completion.

Numerous tests for filling and emptying systems were carried out between 1938 and 1941. In 1941 the Office of the Chief of Engineers authorized the

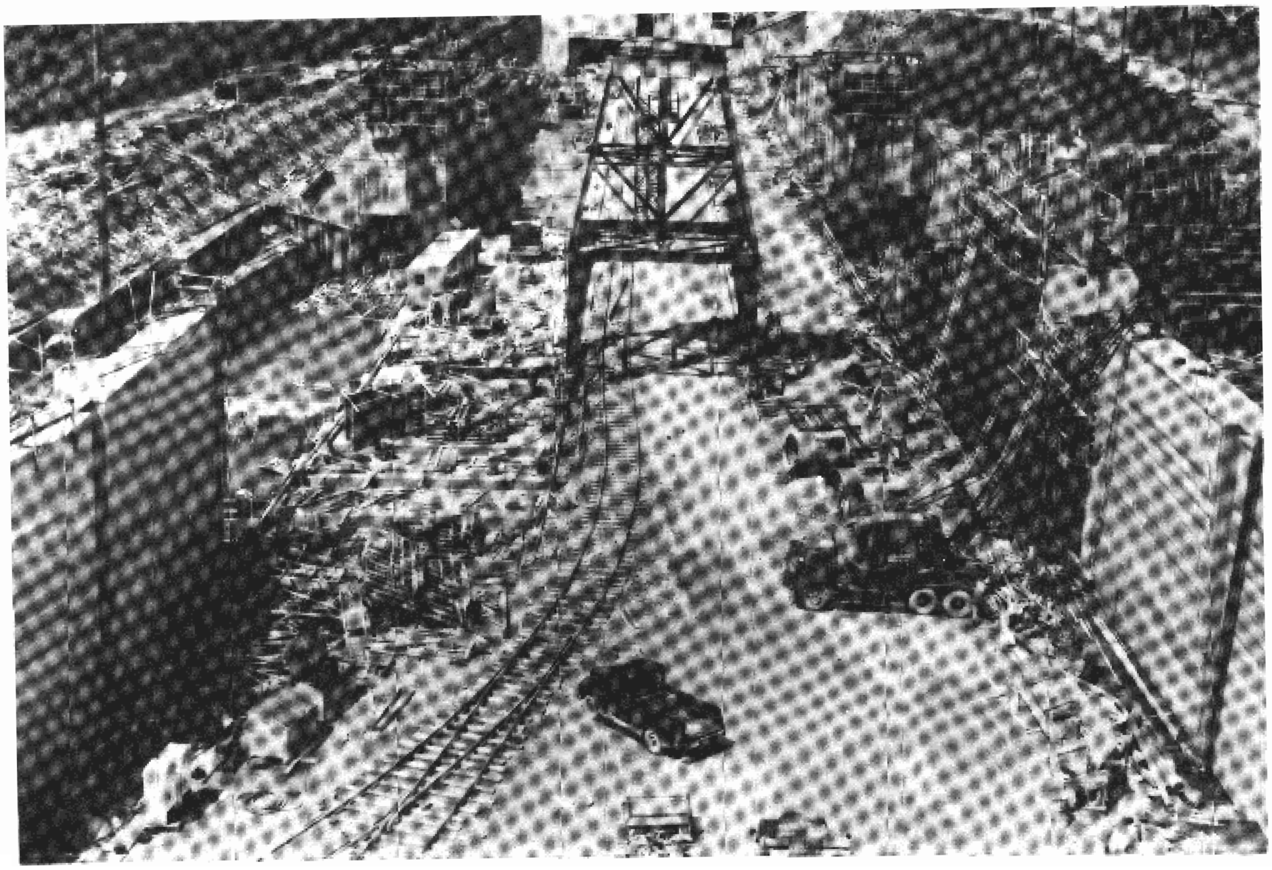
Rock Island District to proceed with detailed plans and specifications for a new lack at the dry dock location and to undertake model studies.

At this stage of the design, District engineers planned to use a Tainter gate In lieu of miter gates at the upper end of the lock. Tainter gates used in several of the dame on the 9-foot channel had given superior performance under the ice conditions on the Upper Mississippi. This Tainter lock gate would submerge to admit boats during locking, rather than opening against the lock walls as the miter gates did.

A dramatic change in planning for new Lock 19 occurred in 1945. Completion of the 9-foot channel had created a bottleneck at Lock 19. Lines of tows often waited many hours to pass through the smaller luck at Keokuk. Responding to studies within the District which showed a clear trend toward heavier and longer tows on the Upper Mississippi, Rock Island District planners recommended to the Office of the Chief of Engineers that the length of the new Lock 19 be expanded to 1,200 feet. The 38.2-foot drop at Keokuk was by far the largest of any lock in the District, and the capacity to lock through in one long tow would be especially timesaving.

With the change in dimensions came a change of location. The Rock Island District proposed to build this new lock on the landward side of the dry dock, almost directly over the site of the Des Moines Rapids Canal.

A hearing was held at Keokuk on August 16, €945, to explain the project to the public and to receive opinions about the lock from navigation interests and others. Several hundred notices were sent out to congressmen, senators, local politicians, corporations and private citizens, but fewer than 15 people showed up at the meeting chaired by District Engineer Lieutenant Colonel John Peil. Japan had surrendered two days earlier, and the whole country wa3 celebrating.



Construction at new Lock 19, taken June 1955.

General opinion toward the project, however, was very favorable, and modest funds for planning were authorized between 1946 and 1949. By 1950 work on the design and plans for the new lock was being carried out by the Rock Island District, by the Upper Mississippi Valley Division at St. Louis, and by the Office of the Chief of Engineers in Washington, D.C.

In 1950 District planners decided against moving the dry dock to another location in the District. Instead, the dry dock would remain at Keokuk for use on an emergency basis, while a service base for storage and repair would be established near the old Le Claire C a d Lock.

Final model tests of the new 1,200-foot lock were performed by the St. Paul District at Government laboratories in Iowa City, Iowa. At this point, plans still called for a Tainter-type upper service gate. A submersible, vertical lift gate was substituted in 1952 just prior to the start of construction.

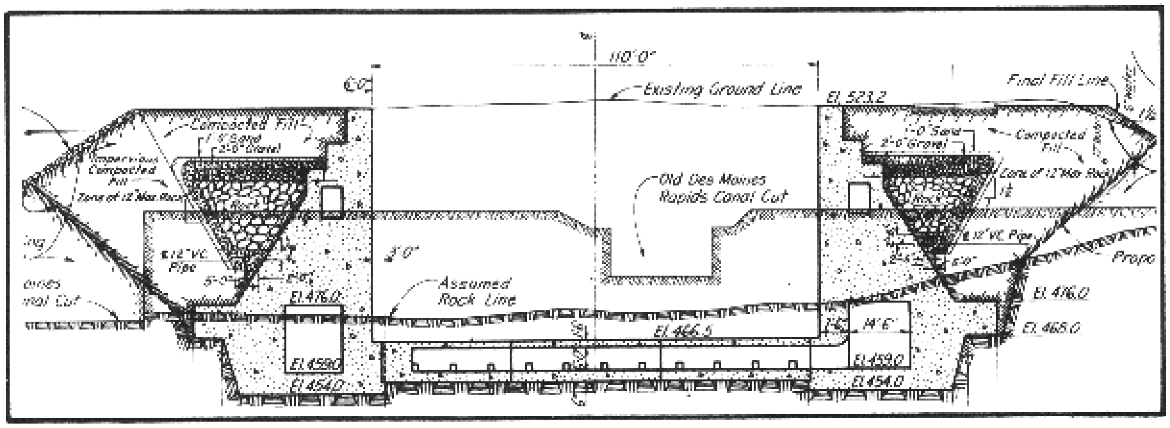
With plans and specifications nearly done, Congress in 1952 appropriated $994,000 to begin construction. While the Korean War brought nearly all other activities in the Rock Island District to a standstill, appropriations for new Lock 19 continued on schedule, an indication of the economical and military importance of the project.

All of the work on the new lock between 1952 and 1957 was contracted out in four stages involving four separate contracts. Stage I consisted of the lower guide wall extending from the lock proper. These guide walls were longer than usual so as to insure a proper lineup for tows. The river guide wall, extended far enough to enclose the swing pier of the Keokuk and Hamilton Bridge downstream from the hock, making passage through the bridge easier and safer. Stage I was begun late in 1952 and completed in April of 1954.

A month later construction began on Stage II, consisting of the lock proper, and lock gates, Tainter valves for filling and emptying, operating machinery, and the esplanade around the lock. Stage II was complete enough to operate by the spring of 1957,

Stages III and IV were smaller contracts, involving mechanical and electrical equipment for operating the lock, and the installation of this equipment. These stages, too, were completed in 1957.

* cross section of the new lock, showing its location atop the old Des Moines Rapids Canal, and its much larger size.



With new Lock 19 nearing completion in the spring of 1957, Rock Island District officials planned a ribbon-cutting ceremony to celebrate the opening scheduled for the second week of May. However, on May 1, while the Stage II contractor was testing the operation of the new lock prior to turning it over to the Corps of Engineers. a tow coming upstream waiting to go through old Lock 19 encountered cross currents caused by the testing and requested permission tu come through the new lock. The contractor received permission from the Rock Island District to do so, and so the *Hawkeye* with 12 barges of coal became the first boat through the lock. The first locking-through took one hour; at the old lock the same tow would have required five hours.

Two weeks later, on Tuesday, May 14, the Rock Island District formally opened new Lock 19. When the lock opened at 8 a.m., the *Lachlan Macleay* of the Federal Barge Linea entered the lack, greeted by only a handful of District employees. The tow of seven barges of steel, sulphur, and coal locked through in one-half hour.

Formal dedication ceremonies for Lock 19 were held on August 19, 1957. In addition to Rock Island District personnel, speakers at the dedication included Assistant Secretary of the Army Dewey Short, Chief of Engineers Major General Emerson C. Itschner, and Iowa Governor Herschel Loveless. The official dedication at 3:00 p.m. followed a luncheon, open house, and parade.

Lock 19 was completed at a cost of $13,500,000, somewhat more than the 1930 estimate of $1,500,000. It still remains the largest and most impressive lock on the Upper Mississippi. It furnishes a usable Bock chamber 110 feet wide by 1,200 feet long. Depth ever the upper sill is 15 feet, with 13 feet over the lower sill. The maximum lift at low water stage is 38.2 feet.

All three lock gates are of steel construction. The downstream gate is a miter type, while both the upper service gate and the guard gate are submersible vertical Eft gates. In addition to protecting the service gate against damage from tows and ice flows, the guard gate serves as a roadway for vehicle access to the old lock and power darn.

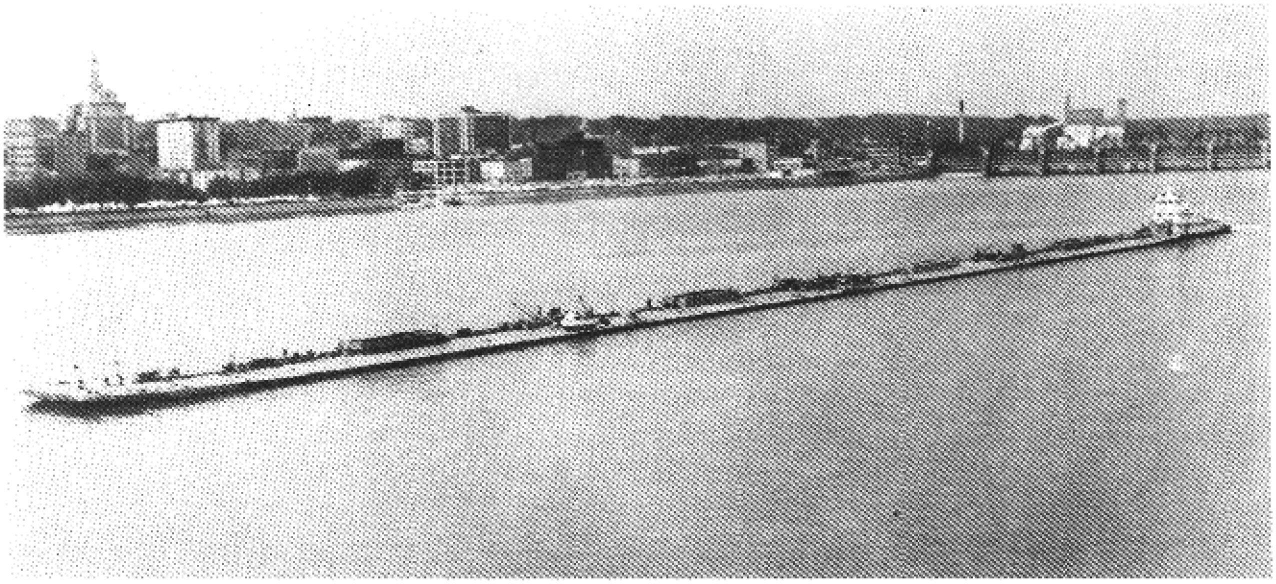
As with all other locks in the Rock Island District, Lock €9 is filled and emptied by gravity. Intake and discharge valves control the water, which enters through intake3 in the upper sill and is distributed to the lock through lockwall culverts. These in turn distribute the water to lateral culverts under the lock floor. The same system is used to &scharge the water at the downstream end of the lock. The filling and emptying system fills the lock chamber in approximately ten minutes and empties it in about nine minutes. Just over 3,800,000 gallons of water are used for each emptying or filling,

Effects of the 9-Foot Channel. The 9-foot channel began to make a difference on the Upper Mississippi even before it was finished. The Wpper Mississippi Wildlife and Fish Refuge Act passed in 1924 authorized the Biological Survey to buy overflow lands along the Upper Mississippi River. Conservationists at first felt that the 9-foot channel would ruin the potential of the valley for a wildlife refuge.

However, as the first pools were filled, the cooperative planning between the Engineers and the conservationists began to show results. In 1937 Ira Gabrielson, Director of the Fish and Wildlife Service, wrote an article in *Scientific American* in which he concluded that the dams. were having a positive effect:

> A fine example of how large dams may help the wildlife resources is developing now on the Upper Mississippi River Wildlife Refuge near Winona, Minnesota. Two of the pools created here by the flood control and navigation dams have relatively stabilized water levels. These dams, which might easily have been so designed as to destroy most of the wildlife value of this great area are actually increasing these values. In the shallow portions of these stabilized pools, which lie outside the navigation channel. water plants, both the submerged acquatic and the emergent vegetation favorable to waterfowl and other marsh-loving birds, are establishing themselves in abundance.[15]

In a later book, Gabrielson pointed out that no single conservation organization could have benefitted wildlife so much as the Army Engineers had in



Modern river traffic is far more sophisticated than the old steam traffic. Here the towboat *Winchester* passes through Pool 16 with a $2,455,200 tow of linseed oil.

their 9-foot channel project.[16] In 1939 the Corps of Engineers turned over 150,000 acres of overflow lands between Davenport and Lake Pepin to the Biological Survey for use as a wildlife refuge.

But of course it was primarily for navigation that the 9-foot channel was developed, and here, too, the effects of the improvement began to show, although World War II held the growth of river traffic to a slower pace. Until 1946, because of the war, traffic remained relatively modest, averaging about 2,000,000 tons of freight per year. Then in 1947 the towboat *Alexander Mackenzie* took a cargo of 18,500 tons up to St. Paul in one trip. By comparison, in 1857 the 22 boats that arrived at St. Paul brought 2,500 tons of freight. The *Alexander Mackenzie*'s single load amounted to ½ the tonnage towed annually by the four packets of the Diamond Jo line between 1900 and 1910.

By 1950 freight passing through the Rock Island District had surpassed 5,000,000 tons; in 1959 the amount reached 10,000,000 tons for the first time. By 1972, freight through the Rock Island District exceeded 25,000,000 tons,[17] while traffic originating in the District or terminating there slightly exceeded 6,000,000 tons. Nearly *every* year continues to find new records set, although the uncertainty of the length of the winter ice period and other problems such as low water, the grain harvest, and the nation's economy all cause river traffic to fluctuate from year to year. Overall, however, river traffic has shown steady growth. In 1980, the tonnage shipped through the Rock Island District exceeded 34,000,000 tons, and August of that year set the highest single monthly cargo total in the history of the 9-foot channel: 4,543,525 tons.

The 9-foot channel has brought about changes not only in the amount of river transportation, but in the methods as well. Gone is the steam engine with its paddle wheel which had been a necessity in the shallow natural channel. In its place have appeared larger and larger diesel towboats. A typical modern towboat operating on the Upper Mississippi is around 165 feet long and perhaps 35 feet wide, with a draft of slightly over 8 feet and powered by as much as 5,000 horsepower.

The standard barge which accompanies these towboats is 195 feet long, 35 feet wide, with an 8- to 9-foot draft. One of these barges can carry 1,500 tons of coal or grain, or up to 10,000 barrels (420,000 gallons) of petroleum products, or 45,000 bushels of grain. Each barge can carry the equivalent of 25 to 35 railroad cars. These barges are made up into tows that often contain 12 to 14 barges, and may contain as many as 15 to 17. Seventeen barges is the practical limit on the Upper Mississippi since it is the most that a double lockage can handle. The record of 17 barges was first set by the towboat *W. S. Rhea* on August 11, 1957; since then tows of 17 barges have become frequent. When locking this many barges through, the first nine barges are sent through the lock, three abreast; the second lockage sends through the remaining eight barges and the towboat (placed in the last row with two barges).

A modern towboat with 14 barges can carry the equivalent of 140 packet steamboats of the kind active on the Upper Mississippi when Colonel Wilson arrived in 1866 to organize the Rock Island District.

Along with an increase in traffic has come an increase in the number of terminals. In 1940 there were four terminals in the Rock Island District; by 1961 there were 70. River traffic today gives no indication of levelling off. The 9-foot channel has done its job well.

Notes

Chapter 9

1. Michael C. Robinson, "The Federal Barge Fleet: An Analysis of the Inland Waterways Corporation, 1924-1939," in *National Waterways Roundtable Papers* (Norfolk, VA: Institute for Water Resources, 1980), p. 148.

2. Ibid., p. 151.

3. Frank Fugina, *Lore and Lure of the Upper Mississippi River* (Winona, Minnesota: Frank Fugina, 1945), pp. 155, 302.

4. *Minneapolis Journal*, August 23, 1929.

5. Raymond Merritt, *Creativity, Conflict & Controversy, A History of the St. Paul District U.S. Army Corps of Engineers* (Washington: Government Printing Office, [1980]), p. 198.

6. See, for example, Davenport *Democrat*, October 13, 1935. Also based on interviews with Corps employees Frank Ashton and Robert Clevenstine.

7. For a brief history of the Clock Tower Building, see Appendix 3.

8. *Report of the Federal Civil Works Program as Administered by the Corps of Engineers, U.S. Army, 1951*, Part 1, Vol. III (Washington, D.C.: Government Printing Office, 1952).

9. St. Louis *Post Dispatch*, July 19, 1939, p. 30.

10. Malcolm Elliott, "The Upper Mississippi River Project with a Discussion of the Movable Gates in the Dam." Paper read before the Western Society of Engineers, Chicago, November 1, 1937 (typewritten). Also, *Upper Mississippi River Navigation Improvement, Providing a 9-foot Channel Depth between Minneapolis and the Misssouri River* (St. Louis: Office of the Division Engineer, 1941).

11. Interview with Robert Clevenstine, June 21, 1973.

12. *Annual Report*, 1934, I, pp. 783-793.

13. *Annual Report*, 1935, I, pp. 1894-1903.

14. Information in the following section on Lock 19 is taken from "The Development of Second Lock No. 19, Keokuk, Mississippi River," a report to the Division Engineer and OCE by Frank W. Ashton, Chief, Engineering Division, Rock Island District. no date. Mimeographed. Rock Island District Historical Files.

15. Ira Gabrielson, "Floods and Wildlife," *Scientific American*, 156 (February 1937), p. 101.

16. Ira Gabrielson, *Wildlife Refuges* (New York: Macmillan Company, 1943), p. 193.

17. *Inland Waterways Journal*, 71 (January 27, 1973).